

MULTIVARIATE ANALYSIS ON CRANIUM MEASUREMENTS OF THREE BREEDS OF GOAT IN CENTRAL JAVA

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Received September 15, 2013; Accepted November 04, 2013

ABSTRAK

Tujuan penelitian ini adalah untuk 1) mengidentifikasi ukuran dan bentuk kranium dari tiga bangsa kambing lokal Jawa Tengah (Kejobong, Kacang dan Peranakan Ettawa), 2) mengetahui efektivitas pengukuran kranium dengan menggunakan analisis multivariat dan 3) memperkirakan jarak genetik antara tiga bangsa kambing. Materi yang digunakan adalah kranium kambing Kejobong, Kacang dan Peranakan Ettawa (PE), jenis kelamin betina yang berumur sekitar 4 tahun (berdasarkan susunan gigi seri) dengan masing-masing kranium sebanyak 30, 10 dan 10 buah. Data yang diambil sebanyak 27 ukuran kranium, dianalisis dengan analisis multivariat yang meliputi GLM, CANDISC, PRINCOMP dan DISCRIM. Analisis yang digunakan untuk menggambarkan jarak genetik antar bangsa adalah UPGMA dari MEGA 5. Hasil penelitian menunjukkan bahwa kambing PE cenderung menunjukkan ukuran terbesar, diikuti oleh kambing Kejobong dan kambing Kacang. Kranium kambing Kejobong memiliki ukuran kecil dengan bentuk yang besar. Hal berbeda terjadi pada kambing Kacang yang menunjukkan ukuran dan bentuk kranium yang relatif kecil. Kranium kambing Kacang menunjukkan ukuran yang lebih kecil (Komponen Utama I atau KU-I = -2) dibandingkan dengan kambing PE (KU-I = 3) dan Kejobong (KU-I = -1). Analisis untuk mengklasifikasikan ketiga bangsa kambing lokal tersebut menunjukkan keakuratan yang sangat tinggi (100%), ditunjukkan dengan tidak adanya kesalahan (0%). Hubungan jarak genetik kambing Kejobong lebih dekat dengan kambing Kacang, dibandingkan dengan kambing PE.

Kata kunci: kraniometri, kambing Kejobong, kambing Kacang, kambing PE

ABSTRACT

The purposes of this study were to 1) identify the size and shape of cranium of three breeds of Central Java local goats (Kejobong, Kacang and Ettawa Grade), 2) examine the effectiveness of multivariate analysis of cranial measurement and 3) estimate genetic distance among three local breeds of goat. The material used was cranium from female Kejobong, Kacang and Ettawa Grade goats, aged for about 4 years (determined on the basis based on eruption of teeth), the number of specimens were 30; 10 and 10, respectively. Twenty seven cranial measurements used to data observed, multivariate analysis of GLM, CANDISC, PRINCOMP and DISCRIM were used to analysis all data observed. UPGMA of MEGA 5 was used to illustrate the distance among breeds. Results showed that Ettawa Grade tended to show the largest size, followed by Kejobong and Kacang goats. Kejobong goat showed small cranium size with large cranium shape. Different things was found in Kacang goats in which cranium size and cranium shape are relatively small. Kacang breed showed the smaller size (Principal Component I or PC-I = -2) compared to Ettawa Grade (PC-I = 3) and Kejobong goat (PC-I = -1). Analysis for classifying three breeds of local goat resulted in high accuracy (100%) as indicated by 0% of erroneous level (0%). Kejobong goat was close to in the genetic relationship to Kacang goat compared to Ettawa Grade goat.

Keywords: craniometry, Kejobong goat, Kacang goat, Ettawa Grade goat

INTRODUCTION

Goats are the potential animals to be developed in Indonesia. Goats have many advantages such as easy maintenance, and prolific that can give birth to twins and can give birth three times in two years. Moreover, goat market prospects are also very promising. Once goats have short reproduction cycle and produce quality meat, they are raised as an extra investment without major labor input by the marginal farmers (Sodiq and Sumaryadi, 2002).

Central Java have the highest goat population in Indonesia. According to the Direktorat Jenderal Peternakan dan Kesehatan Hewan (2013), goat population in 2012 in Central Java were 3,889,878 heads. In Central Java province, there are four local breeds of goats, namely Kacang, Jawarandu, Ettawa Grade and Kejobong goats (Kurnianto *et al.*, 2013). In developing local goats, it needs to study about the potential of phenotypically to see the diversity of goats. Kacang is an indigenous breed of goat found in Indonesia. Ettawa Grade goats are descended originally from crossing between Kacang and Ettawa goats (Sodiq and Haryanto, 2007). Study about Kejobong goat is lack. Kejobong goat population is mostly centralized in Kejobong Sub-district, Purbalingga Regency, Central Java (Purbowati and Rianto, 2010). The number of Kejobong goats in Purbalingga was about 43,708 heads (Dinas Peternakan dan Perikanan Kabupaten Purbalingga, 2011).

Multivariate analysis is a method for rapid and cheap to identify goat breeds and has been widely used to study the breed characterization of goat in Indonesia (Batubara *et al.*, 2011; Kurnianto *et al.*, 2013), goat in Nigeria (Yakubu *et al.*, 2010; Okpeku *et al.*, 2011; Yakubu *et al.*, 2011), goat in Burkina Faso (Traore *et al.*, 2008), goat in Ghana (Birteeb *et al.*, 2012), goat in Saudi Arabia (Aziz and Al-Hur, 2013). Skeletal characters including cranium form reveal the highest heritability of all the quantitative traits. Therefore, application of an appropriate statistical analysis to the skeletal measurement can used to identify a strain within an animal species and estimate closeness of relationships among different strains (Goto *et al.*, 1991).

The purpose of this study was to identify the size and shape of cranium of three breeds of Central Java local goats (Kejobong, Kacang and Ettawa Grade). Besides, the purpose was to examine the effectiveness of multivariate analysis

of cranial measurement, and to estimate genetic distance among three local breeds of goat in Central Java.

MATERIALS AND METHODS

This research was conducted in Purbalingga and Grobogan regencies, Central Java Province, Indonesia. Purposive sampling method was applied to determine the location on the basis of population density of the goat breeds. The materials studied were female goats and aged about 4 years old (determined on the basis based on the teeth eruption). The number of specimens for Kejobong, Kacang and Ettawa Grade goats were 30, 10 and 10, respectively. Sample was collected and measured from slaughter houses in Purbalingga and Grobogan respectively.

Twenty seven cranial measurements used in this study, was based on the definition of Ozcan *et al.* (2010) as shown in Figure 1 including the important measuring points. All measurements were taken with sliding or spreading calipers and were recorded to the nearest 0.1 millimeters.

Statistical analysis

The data were subjected to used for univariate and multivariate analysis using General Linear Model (GLM) procedure. CANDISC procedure (SAS, 2004) was used to perform a canonical discriminant analysis and to compute squared Mahalanobis distance. Squared Mahalanobis distance obtained then was administered to MEGA 5 to construct phylogeny through UPGMA (Unweighted Pair-Group Method with Arithmetic Mean) tree (Tamura *et al.*, 2011). The between-breed squared Mahalanobis distance matrix was computed as Mahalanobis distance that is written as:

$$D_{ij}^2 = (X_i - X_j)' \text{Cov}^{-1} (X_i - X_j)$$

Where:

D_{ij}^2 : distance between i^{th} breed and j^{th} breed.

Cov^{-1} : the inverse of the covariance matrix of measured variable X.

X_i and X_j : are the means of variable X in i^{th} breed and j^{th} breed, respectively.

PRINCOMP procedure (SAS, 2004) was performed to determine principal component analysis (PCA). DISCRIM procedure was performed to evaluate the misclassified of breed and Mahalanobis distance among breeds.

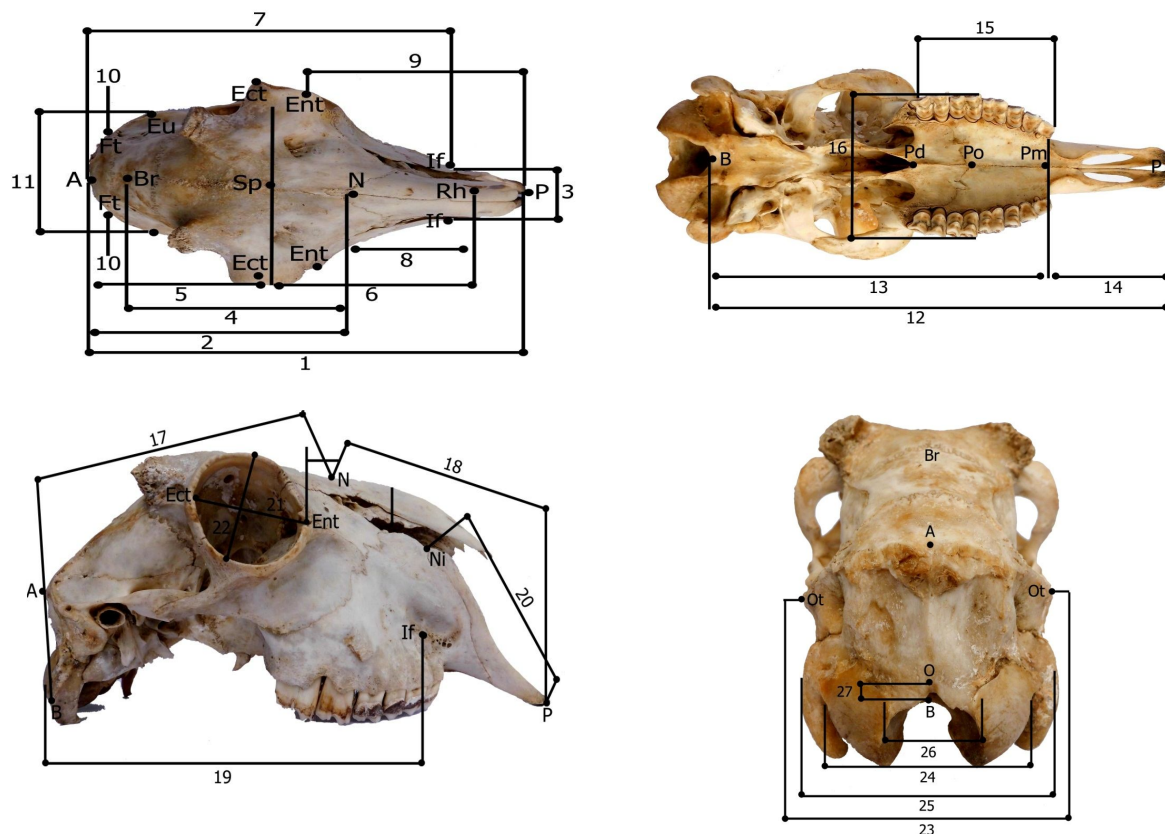


Figure 1. Measurements of the Cranium of the Kejobong, Kacang and Ettawa Grade Goats

where:

- | | |
|--|--|
| <p>1 : Profile length
 2 : Median frontal length
 3 : Greatest breadth across the premaxillae
 4 : Frontal length
 5 : Upper neurocranium length
 6 : Facial length
 7 : Akrokranium-infraorbitale of one side
 8 : Greatest length of nasals
 9 : Short lateral facial length
 10 : Least breadth of the parietal
 11 : Greatest neurocranium breadth</p> | <p>12 : Basal length
 13 : Short skull length
 14 : Premolare-prosthion
 15 : Length of the cheektooth row
 16 : Greatest palatal breadth
 17 : Neurocranium length
 18 : Viscerocranium length
 19 : From the aboral border of one occipital condyle to the infraorbitale of the same side
 20 : Lateral length of the premaxilla
 21 : Greatest inner length of the orbit
 22 : Greatest inner height of the orbit
 23 : Greatest mastoid breadth
 24 : Greatest breadth of the occipital condyles
 25 : Greatest breadth of the bases of the paroccipital processes
 26 : Greatest breadth of the foramen magnum
 27 : Height of the foramen magnum</p> |
|--|--|

RESULTS AND DISCUSSION

Cranium measurements of three breeds of goat are presented in Table 1. Based on the analysis for the result measurements of the cranium among goat breeds, there was differences

among three local goat breeds ($P < 0.05$) for all variables cranium size, except on variables 3 (greatest breadth across the premaxillae), 14 (premolare-prosthion) and 16 (greatest palatal breadth). It shows that almost all variables were influenced by differences in cranial size goat

Table 1. Cranium Measurements of Three Breeds of Goat

Variable	Breed		
	Kejobong	Kacang	Ettawa Grade
 cm		
1	22.78±1.13 ^b	22.73±0.79 ^b	24.07±0.69 ^a
2	12.99±0.67 ^{ab}	12.60±0.87 ^b	13.17±0.49 ^a
3	3.59±0.37 ^a	3.45±0.23 ^a	3.48±0.25 ^a
4	10.44±0.75 ^a	9.78±0.81 ^b	10.44±0.44 ^a
5	10.13±0.82 ^b	10.17±1.41 ^b	11.22±0.61 ^a
6	15.76±1.10 ^a	14.39±0.89 ^b	16.21±0.95 ^a
7	15.99±0.88 ^b	15.84±0.51 ^b	16.84±0.51 ^a
8	11.77±0.95 ^b	11.54±0.86 ^b	13.50±1.06 ^a
9	13.25±0.86 ^b	13.26±0.54 ^b	13.99±0.46 ^a
10	3.07±0.27 ^a	2.83±0.31 ^b	3.18±0.39 ^a
11	5.30±0.31 ^b	5.05±0.68 ^b	5.68±0.40 ^a
12	19.88±1.33 ^{ab}	19.75±0.70 ^b	20.73±0.74 ^a
13	14.55±0.86 ^b	14.29±0.45 ^b	15.32±0.56 ^a
14	5.34±0.36 ^a	5.36±0.27 ^a	5.58±0.40 ^a
15	7.00±0.42 ^{ab}	6.82±0.19 ^b	7.28±0.37 ^a
16	6.42±0.47 ^a	6.43±0.35 ^a	6.43±0.37 ^a
17	13.13±0.68 ^a	12.46±0.56 ^b	13.39±0.51 ^a
18	13.63±1.08 ^b	13.19±0.77 ^b	15.16±0.83 ^a
19	15.48±0.94 ^b	15.41±0.57 ^b	16.38±0.56 ^a
20	9.28±1.00 ^b	9.85±0.92 ^b	11.11±0.54 ^a
21	3.67±0.27 ^b	3.77±0.15 ^b	3.98±0.13 ^a
22	3.41±0.22 ^{ab}	3.31±0.19 ^b	3.50±0.18 ^a
23	7.74±0.45 ^b	7.76±0.25 ^b	8.47±0.33 ^a
24	5.34±0.32 ^a	4.98±0.19 ^b	5.53±0.26 ^a
25	6.95±0.41 ^b	6.86±0.26 ^b	7.61±0.34 ^a
26	2.09±0.33 ^a	1.82±0.17 ^b	2.01±0.30 ^{ab}
27	2.27±0.21 ^a	2.09±0.17 ^b	2.26±0.23 ^a

Different superscript at the same row indicate differ significantly ($P<0.05$); Variables see to Figure 1.

breeds. Cranium is part of the body that is genetically derived from a particular breed, so that every breed has a cranial measures different compared to other breeds (Saparto, 2006).

Most of variable size cranium of Ettawa Grade were the greatest size, it were followed by

Kejobong and Kacang goats. According to Pamungkas *et al.* (2009), Ettawa Grade goat is the result of a cross between a Ettawa goat (from India) with Kacang goat, which looks similar performance but smaller than Ettawa goat.

The principal component analysis has often

Table 2. Eigenvalue and its Contribution in Each Principal Component

Principal Component (PC)	Eigenvalue	Contribution Ratio	Cumulative Contribution Ratio (%)
I	8.98990275	0.5959	59.59
II	1.51030885	0.1001	69.60

Table 3. Eigenvector of Each Principal Component

Variables	PC-I	PC-II
1	0.308451	0.081872
2	0.132184	0.395145
3	0.007479	0.031295
4	0.097083	0.413347
5	0.191190	0.293483
6	0.313542	-0.088548
7	0.233882	0.144768
8	0.331978	-0.472760
9	0.231412	-0.017523
10	0.022805	0.017856
11	0.070983	-0.051922
12	0.338330	0.127886
13	0.245176	0.088636
14	0.077418	0.023495
15	0.057923	0.053863
16	0.078748	0.050290
17	0.154087	0.245713
18	0.311582	-0.462315
19	0.258493	0.080384
20	0.321781	-0.021092
21	0.053546	0.020524
22	0.042859	0.017730
23	0.119950	0.030810
24	0.059083	-0.035525
25	0.120225	0.000902
26	0.016795	-0.093266
27	0.019675	0.026679

Variables see to Figure 1.

been applied to discriminate animal population (Blackith and Reyment, 1971) and the efficiency of this method for cattle has been presented in previous report (Hayashi *et al.*, 1981; Nishida *et al.*, 1983; Saparto, 2006). Each of principal component used in this study was extracted from the covariance matrix of 27 cranial measurements. Table 2 shows the eigenvalue and its contribution in each principal component (PC). Result indicated that 69.60% of cumulative contribution ratio from the PC-I to the PC-II. This means that the first two PCs extracted accounted for more than 69% of morphometrical variation information. Saparto (2006) who used several variables cranium in Indonesian native cattle showed the contribution of PC-I amounting to 51.97% and PC-II was 67.82%. Hayashi *et al.* (1982) reported on the several variables of native cattle breed in Asia showing the contribution of PC-I amounting to 65.3% and 9.3% at PC-II.

Table 3 presents eigenvectors of PC-I and PC-II. In PC-I, all eigenvectors had positive values, while in PC-II, eight eigenvectors representing length of cranium showed negative values. According to Hayashi *et al.* (1982), in morphometrical application of the principal component analysis, the first component was acceptable as size, and the second one as a shape. The scattering diagram of 3 breeds of goats constructed by PC-I and PC-II is presented in Figure 2.

Figure 2 presents plotting membership of breed based on the cranium measurements. Ettawa Grade showed the largest size proved by positive value of PC-I and negative value of PC-II, followed by Kejobong breed. Kejobong goat breed showed the negative value of PC-I and positive value of PC-II, showing that Kejobong goats were small cranium size with large cranium shape. Different thing was found in Kacang goats, in which the cranium size and shape were relatively small due to the negative value of PC-I and negative value of PC-II. Kacang breed showed the smaller size compared to Ettawa

Grade and Kejobong breed.

According to Kurnianto *et al.* (2013), historically, Kacang goat is the indigenous breed of Indonesia, included in Central Java. Ettawa Grade goat is a breed originating from the grading up of goat breeds introduced from India (Ettawa or Benggala) and local breed from hundreds years ago. Kejobong goat is a new breed that is the result of crossbreeding between Ettawa and Kacang breeds. Kejobong goats initially were only found in Purbalingga Regency, Central Java, especially in Kejobong District.

In general, the goats among several breeds suspected of having genetic relationship according to body measurements. According to Suparyanto *et al.* (1999), phenotypic similarity in body size of various breeds is a reflection of the magnitude of a mixed group of breeds that

occurred either by the mutation breeder modified or naturally occurring.

Discriminant function analysis to determine the percentage of erroneous level of grouping into their own breeds on the basis of cranium measurements is presented in Table 4. Using Canonical Discriminant analysis for classifying three types local goat breeds resulted in the high accuracy as indicated by 0% of misclassification. This suggests that there was a high uniformity due to the homogeneity of the breed. The results of this investigation suggested that cranium analysis is applicable to discriminate of three types goat breed.

In the discriminant analysis, the Mahalanobis distance based on the 27 measurement were calculated among three breeds. Because the cranium size and shape are highly heritable traits,

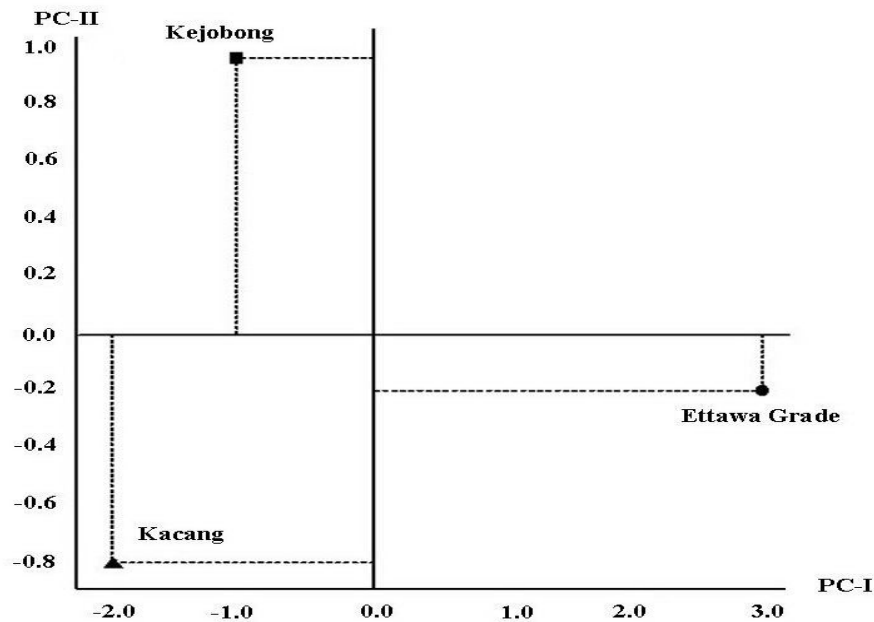


Figure 2. Plot of Membership on Average Cranium Measurements of Three Breed of Local Goat Breeds

Table 4. Results of Classification Analysis by Means of Discriminant Analysis

Breed	Kacang Goat	Kejobong Goat	Ettawa Grade Goat	Total
Kacang Goat	10 (100)	0 (0)	0 (0)	10 (100)
Kejobong Goat	0 (0)	30 (100)	0 (0)	30 (100)
Ettawa Grade Goat	0 (0)	0 (0)	10 (100)	10 (100)
Total	10 (20)	30 (60)	10 (20)	50 (100)

Number in the bracket indicates % of classification rightness

Table 5. Mahalanobis Distance Among the Three Breeds of Local Goat Based the Cranial Measurement

Breed	Kacang Goat	Kejobong Goat	Ettawa Grade Goat
Kacang Goat	0	39.73	27.30
Kejobong Goat	39.73	0	55.88
Ettawa Grade Goat	27.30	55.88	0

the distance may reflect the genetic distance between breeds (Saparto, 2006). Table 5 shows the Mahalanobis distance among three breeds of local goat. Kacang goat showed the nearest distance to Ettawa Grade. Kejobong goat had a closer distance with Kacang goat, compared to Ettawa Grade goat.

CONCLUSION

Three breeds of local goats in Central Java could be categorized into two major groups on the basis of cranium measurements, where the first group was of Kacang and Ettawa Grade goats, and the second group was Kejobong. Kejobong goat had a closer relationship with Kacang goat than to Ettawa Grade goat.

ACKNOWLEDGMENTS

This research was partly financed by *Riset Unggulan Daerah - Balitbang Provinsi Jawa Tengah 2013*. The authors would like to thank Head of Animal Husbandry Service at Purbalingga and Grobogan Regencies for allowing the research and their staffs for gathering data. The authors also thank research team of Kejobong goat for good cooperation.

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